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(54) Helical conveyors for the transport of spent radioactive fuel

(57) A jigging conveyor, of the type used in the processing of spent radioactive fuel, comprising a helical ramp (8) with a vertical axis, has steps (11) on its carrying surface (10). Each step (11) comprises a flat surface (12) and a shoulder (13) which are angled with respect to the horizontal and relative to each other in such a way that when the conveyor is in operation, the forward motion of the solid aggregates transported by the conveyor is permitted but the backward motion thereof is limited.

The flat surfaces (12) also slants to the horizontal by an angle (ß). A drainage channel can be formed in the ramp (Fig. 3, not shown).

Actuating means (19) and a traction mechanism (Fig. 4) move the conveyor in a to-and-fro motion in a horizontal plane. The traction mechanism comprises a shaft (18) joined by means which can be dismantled by remote control in a zone inaccessible to staff and to the actuation means (19) in a zone accessible to staff. Access to the actuation means (19) allows for regular maintenance or replacement of parts.

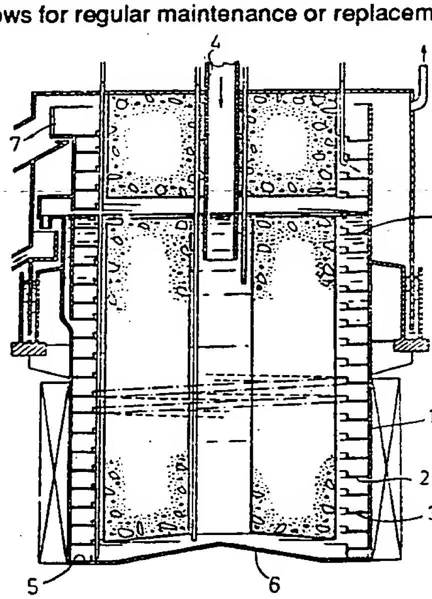

FIG.1

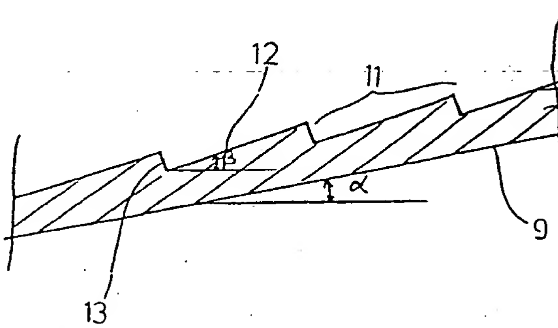

FIG.2

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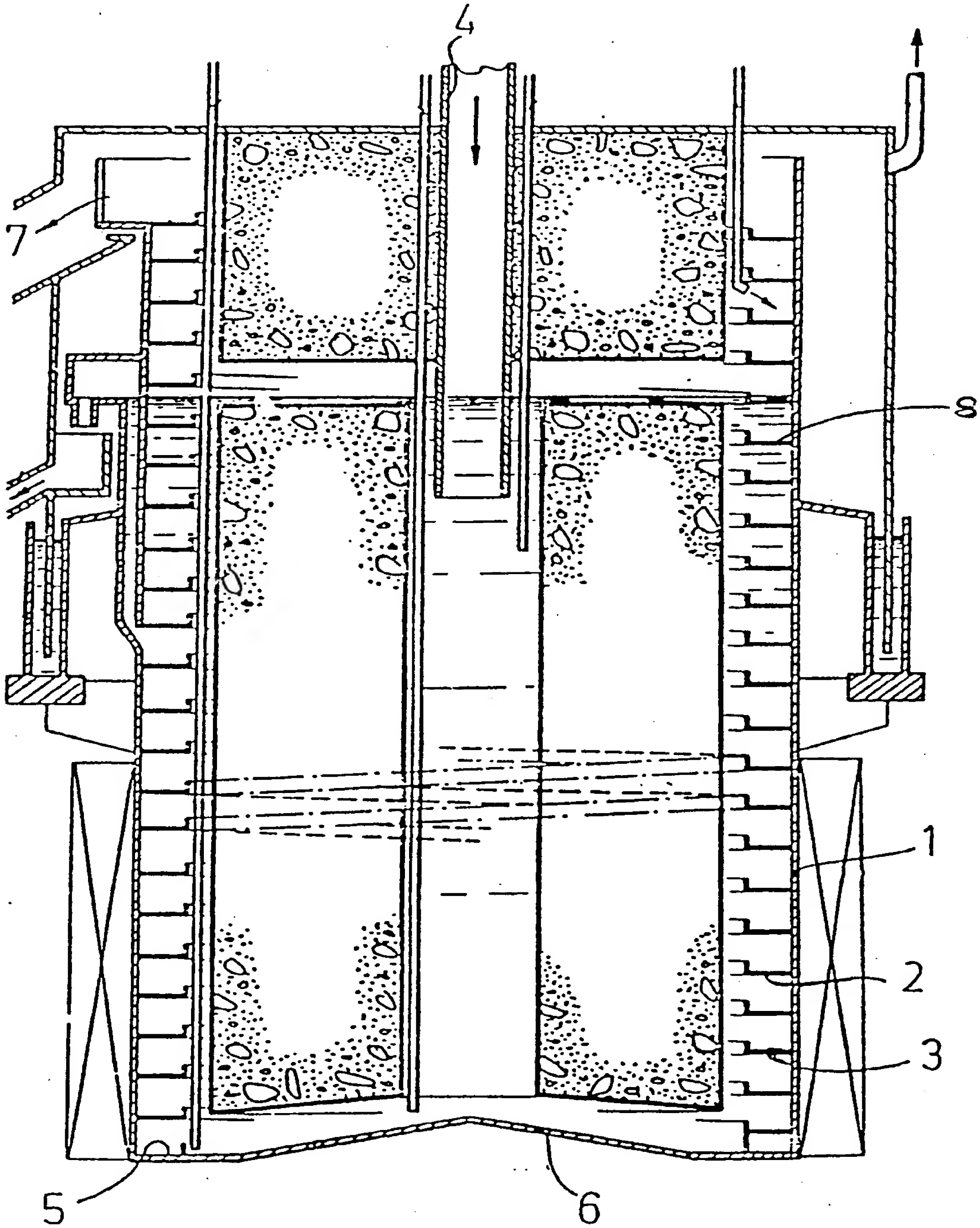
FIG.1



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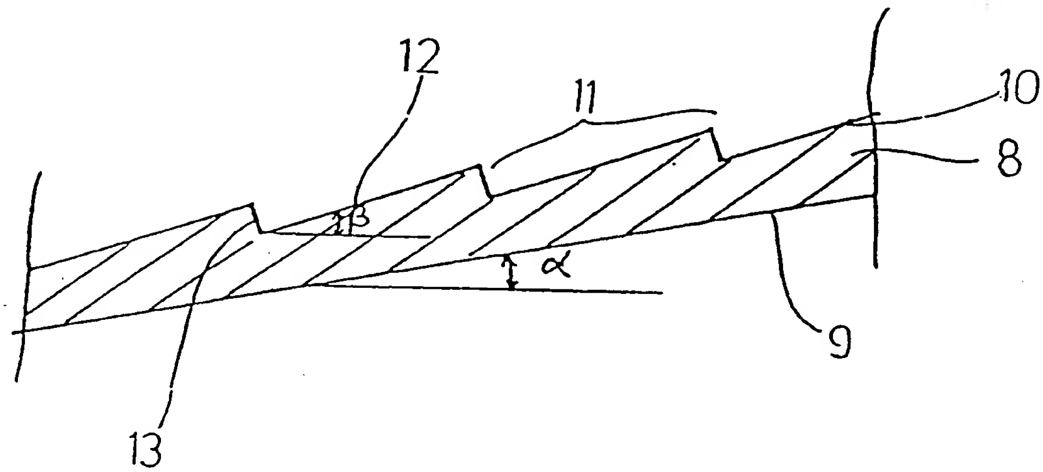

FIG.2

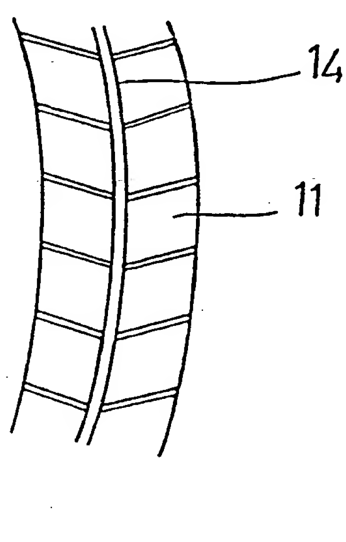

FIG. 3

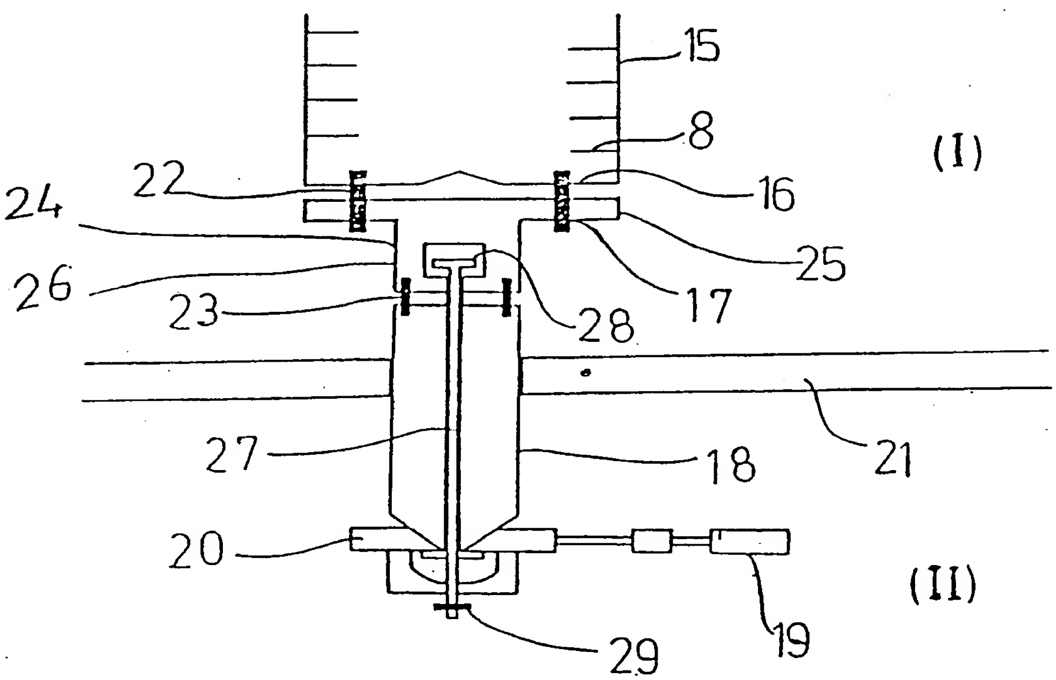

FIG.4

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Helical conveyors for the transport of spent radioactive fuel

The invention relates to an improvement in helical shaker conveyors used in the reprocessing of spent radioactive fuel.

In French Patent 2 474 469 a similar conveyor is described, used in particular for the dissolution of fuel contained in spent elements removed from breeders.

Figure 1 illustrates an earlier model of the device. The following reference numerals refer to this earlier invention.

According to Figure 1, the conveyor comprises a cylindrical reservoir or tank 1 having a vertical axis, to the sides of which a helical ramp 8 is fixed, coaxial to the reservoir and provided with turns. The pieces of spent fuel (composed of a metal sheath containing the fuel in the form of fragments of various sizes) are introduced through the chute 4 positioned within the top portion of the vessel and fall to the bottom of the vessel where they are brought to the bottom 5 of the helical ramp because of the conical form of the bottom 6 of the vessel.

The ramp moves in a to-and-fro manner around its axis and in the horizontal plane which, when the forward and backward movements are correctly selected, has the effect of making the pieces move up the ramp.

When the pieces have come upwards on the ramp, they are left to soak in the liquid contained in the reservoir and the fuel which they contain is dissolved during this time. Only the shells (the pieces of sheath) then remain.

These shells are freed from the residual liquid which they contain when they pass along the non-submerged part of the ramp in the upper part of the reservoir. They leave the conveyors by the chute 7.

A similar device is also used for rinsing shells taken out of fuel elements from various reactors (e.g.

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PWR, BWR, fast neutron reactors), when dissolution of the fuel has already been performed in another plant.

In these two applications, the conveyor is positioned in a zone prohibited to operating staff as the products being processed produce much radiation and/or contamination.

The ramp of the conveyor in the earlier version of the device is caused to move by a jack positioned in the prohibited zone; on the end of its rod it has a means of linkage attached to the outside of the vessel.

It is desirable in the nuclear industry for staff to have access to the means of movement for its regular maintenance or replacement, and access should be allowed subject to all possible safety precautions. The previous model of the conveyor only allowed remote service using remote manipulating equipment because the jack was positioned in the prohibited zone; this entailed performing more delicate operations and limited the choice of material to those resistant to radiation and corrosion, resulting in higher installation costs.

In addition, in the previous model of the conveyor, with the rod of the jack serving as the actuation means joined by its end to the vessel, it requires considerable travel of this rod for the ramp to reach sufficient speed in the direction of the rising helix (moving the shells forward) or for the ramp to have time to stop in the direction of the descending screw causing the minimum backward motion of the shells.

In the nuclear industry it is desirable for this travel to be reduced to limit movement of the ramp, or of the vessel if the ramp is mounted on the inner wall of the vessel.

Moreover, accumulation of undissolved nuclear fuel above a certain level is unacceptable when dissolving spent fuel, as is interruption of flow when rinsing shells. The operator should therefore be able to guarantee that the solid aggregates will remain in the conveyor for a

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reasonable time when it is used for dissolution, or to guarantee a moderate flow rate when it is used for rinsing shells.

For all these reasons of ensuring safety in industrial use, the improvement of the screw shaker conveyor described in French Patent 2 474 469 was made.

The present invention relates to a helical conveyor which comprises a helical ramp serving to transport solid aggregates, positioned in a vessel with a vertical axis, situated in a prohibited zone and containing liquid, and at least partly immersed in this liquid; this ramp is mounted on the inner wall of the vessel and subjected to a to-and-fro motion around its axis and in the horizontal plane by at least one actuation means on its surface carrying the solid aggregates the ramp has steps, each including a flat surface and a shoulder, the steps being arranged so as to allow the aggregates to move forwards and to limit their backward motion.

Each step has a flat surface and a shoulder. The steps make it possible for the shells (or solid fuel elements in general) to come to rest against these shoulders if they move backwards. As the backward movement of the solids on the ramp is then limited, the travel of the rod of the jack is likewise reduced.

The flat surface of each step is at a noticeable slant to the direction of the ramp; in other words, the flat surface is at a greater angle of slant (to the horizontal axis) than that of the ramp.

The length of the flat surface of the step, the angle of slant of the flat surface, the height of the shoulder and its angle to the flat surface are selected by the specialist taking into account the nature of the solids to be processed, the flows to be provided and the possible speeds and accelerations of the ramp.

It is preferable for the flat surface and its shoulder to extend across the width of the ramp.

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It is also preferable for all the steps to be identical, but this arrangement is not essential.

In a preferred embodiment of the invention, the ramp includes at least one drainage channel, open where the shoulders and flat surfaces intersect. This construction makes it possible to avoid the accumulation of small particles and swarf, on their own or mixed with liquid, against the shoulders. These small particles, situated at the intersection of the shoulders and the flat surfaces then flow away into the drainage channel because of the slant of the ramp.

It is advisable to set each flat surface at a slant to the channel in order to facilitate this flow. It is advantageous to position the channel on the centre axis of the ramp, with the flat surface slanting from each side towards the channel. The channel then consists, for example, of an opening formed in the upper surface of the ramp supporting the solid aggregates.

The channel may be situated on the edge of the ramp adjoining the vessel, against which the solid aggregates are driven by the effect of the accelerations created. In this case, it is appropriate to provide openings in the channel between the ramp and the inner wall of the vessel.

One or more channels may oe provided, as required. Each channel should have openings in the zones of intersection of the shoulders and the flat surfaces. The channel may also be open along its whole length.

Another feature of the invention is that the means of movement is situated in a zone accessible to staff and acts on the lower end of a shaft coaxial to the vessel, this shaft being joined, at the level of its lower part which is situated in the zone to which staff have access, to the means of movement.

Various means of actuating of the ramp can be used, for example jacks, a motor with an eccentric or a cam system. Jacks are preferable (a pneumatic, hydraulic or servo-jack). They are selected because of their rapid response to a command; it is clearly advantageous for this time to be minimal in order to reduce the intervals between the phases of motion, and pneumatic and servo-jacks, which have advantages in this respect, are therefore preferred. On the other hand, they may not have enough power if the conveyor is large and/or flow is high, in which case hydraulic jacks are preferable.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 2 is a cross-sectional side view of a portion of the ramp according to the invention;

Figure 3 is a top plan view of a portion of the ramp showing a drainage channel;

Figure 4 is a cross-sectional side view of the means of traction and of actuation according to the invention.

In Figure 2, the ramp 8 has a slanting lower surface 9 (the slant of the ramp) and a surface 10 carrying the solids (fuel elements or sheaths) and equipped with steps 11. These steps have a flat surface 12 and a shoulder 13.

The flat surface 12 slants (in relation to the horizontal axis); its slant β (in relation to the horizonal axis) is clearly greater than the slant α of the surface 9. The length of the surface 12 is called the 'step'.

At its lower end, each surface 12 has a shoulder 13 extending to a certain height and set at an angle, preferably of 90°, to the surface 12. The angle should be sufficiently wide for the solids to be able to escape from it and to limit accumulation against the shoulder when the screw rises. It can be clearly seen in operation that the solids advance freely on the flat surface 12 and come to press against the shoulder 13 when the ramp

does not have enough speed to make them move forward.

Figure 3 shows a preferred embodiment with a drainage channel 14 positioned along the centre axis of the ramp 8.

An opening is formed in the surface 10 supporting the solid aggregates and equipped with steps 11. The steps are machined so that their flat surfaces 12 slant towards this opening. The surfaces 12 are also set at a slant (with an angle of $\beta - \alpha$) to the slant of the ramp. The width of the channel 14 is less than the smallest dimension of the solids being carried (for example, the diameter of the shells which are of generally cylindrical shape) to prevent these from falling into the channel. The depth of the channel 14 is selected by the expert, dependent on the thickness of the ramp.

The channel could equally well have been provided to one side of the ramp, or several could be provided.

Figure 4 shows the vessel 15 with its helical ramp 8 mounted on the inner wall of the vessel. At 16 the bottom of this vessel is shown.

The actuation means 19 is situated in the zone II accessible to staff, separated from the prohibited zone I by a biological protection slab 21 (the continuity of the biological protection is ensured at the point where the shaft 18 passes through the slab).

The means of linkage 17 between the bottom 16 of the vessel and the shaft 18 can be dismantled by remote control, so it is possible to release the coupling and the mechanical link between the bottom and the shaft. The shaft is withdrawn by its lower part situated in the zone II after removal of the actuation means 19.

The invention can provide an advantageous embodiment of the coupling and the mechanical link, facilitating dismantling of the shaft 18.

In this embodiment, shown in detail in Figure 4, the means 17 forming the link between the bottom 16 of the vessel and the shaft 18 consists of mechanical links 22 and 23 joining an intermediate component 24 respectively to the bottom 16 of the vessel and to the shaft 18. This component should preferably include a plate 25 positioned under the bottom 16 and preferably of the same dimensions as it, and a cylindrical part 26 having approximately the same diameter as the shaft 18 and coaxial to the shaft.

The links 23 can be dismantled by remote control, for example, by remote manipulating equipment positioned in zone I in order to release the mechanical link between the component 24 and the shaft 18.

In this advantageous embodiment, to ensure reliable traction of the vessel and maintain the mechanical link in case of failure of the links 23, the component 24 and the shaft 18 are locked together by a rod 27 equipped with a key 28 at its upper end.

The component 24 and the shaft 18 have openings within which the rod with its end in the form of a key 28 are allowed to slide and which allow the key 28 to press on the inner edge of the opening in the component 24 to block the rod. It is advantageous for this key 28 to be of rectangular form, in which case it is enough to turn the rod through 90° to block it; the rectangular key presses with its full length on the lower edge of the opening formed in the intermediate component 24. A key of any other shape which has the same functions would also be suitable.

At the lower end of the rod there is a clamping device 29 which can be dismantled (for example a nut which screws onto the thread of the rod) serving to lock the rod in place in the device.

This improved device considerably increases the reliability of operation in a radioactive environment.

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The bottom 16 is joined by the links 17 to the shaft 18 which lies on the same axis as the vessel and which forms the means of traction of the ramp.

It is appropriate for the actuation means 19 to be in the form of a jack acting on a plate 20 positioned on the end of its rod, with this plate joined to the lower end of the shaft 18.

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CLAIMS

1. A helical conveyor for the transport of spent radioactive fuel and/or the sheaths thereof in the reprocessing of the fuel, comprising a vessel with a vertical axis, situated in a zone inaccessible to operating staff, and arranged to contain liquid and holding a helical ramp with a vertical axis, at least partly immersed in this liquid; the ramp being mounted on the inner wall of the said vessel and being arranged to move in a to-and-fro motion around its axis and in the horizontal plane when subjected to actuation means and a traction mechanism, characterized in that on the surface supporting the said solid aggregates, the ramp has steps, each step including a flat surface and a shoulder, and being arranged so as to allow the forward motion of the aggregates and to limit the backward motion thereof.

2. A conveyor according to Claim 1, in which the ramp is provided with at least one drainage channel which has an opening at the point of intersection of the shoulders and the flat surfaces.

3. A conveyor according to Claim 2, in which the flat surfaces of the steps slant towards the channel.

4. A conveyor according to Claim 2 or 3, in which the channel is positioned along the centre axis of the ramp.

5. A conveyor according to Claim 2 or 3 in which the channel is situated at the edge of the ramp, near the inner wall of the vessel.

6. A conveyor according to any preceding claim , in which the traction mechanism comprises of a shaft on the same axis as the vessel which is joined at the level of its upper part to the bottom of the said vessel by means which can be dismantled by remote control and joined by its lower part, situated in the zone accessible to staff, to the actuation means.

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7. A conveyor according to Claim 6, in which the shaft is joined to the bottom of the vessel by means of an intermediate component, positioned on the axis of the vessel, the intermediate component comprising a plate, positioned under the bottom of the said vessel and joined thereto by mechanical means, and a cylindrical part, joined to the upper end of the shaft by mechanical means, and in which the intermediate component and the shaft are locked together by a rod equipped at its upper end with a key and at its lower end with a clamping means, the rod being engaged in axial openings formed in the shaft and the intermediate component.

8. A conveyor according to any preceding claim, in which the means of actuation is a jack selected from pneumatic, hydraulic or servo-jacks.

9. A conveyor for the transport of spent radioactive fuel, substantially as hereinbefore described with reference to the accompanying drawings.

10. A conveyor for the transport of spent radioactive fuel when linked to a drive means, substantially as hereinbefore described with reference to the accompanying drawings.

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